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AUTHOR Hawkins, Jan
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ABSTRACT

With increasing attention being given to the importance of microcomputers in the schools, there is concern about how new teachers can best be prepared to use the new technology effectively. This paper presents a perspective on teacher training based on three categories in which computers may be used in the classroom: to provide unique learning experiences that take advantage of special features of the technology; to provide information about, and practice with, the technology itself; and to influence social aspects of classroom life. The paper briefly describes three different types of software which have been developed to address the issues above: a word processor to influence children's writing skills; three pieces of software for teaching science and math concepts to fourth through sixth graders; and a LOGO software program to teach children to collaborate while learning programming skills. It is concluded that during teacher preservice education, students should be made aware of the options available for using the computer as a tool in their curricula, and how to make critical choices for integrating it with their teaching goals. (Author/THC)

CENTER FOR CHILDREN AND TECHNOLOGY

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Bank Street College of Education

610 West 112th Street . NY, NY 10025

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THE FLEXIBLE USE OF COMPUTERS IN CLASSROOMS*

Jan Hawkins

In recent years, computer technology has become increasingly available to many people in a wide variety of settings. That impact is being felt in the educational world. As part of the widespread incorporation of technological tools into our society, schools, colleges and other educational settings have been rapidly acquiring computers. They are appearing in all parts of the country and at all grade levels. Children are exposed to them at school and in homes, and it is frequently predicted that computers will revolutionize education in this country. The flexibility of computers, through appropriate software and their capability for providing large amounts of information that can be used selectively, make them a particularly important innovation for education.

At Bank Street, we frequently hear educators ask such questions as: What are computers good for? How do we prepare teachers to take advantage of them? These two questions are similar in that good preparation means helping students to develop a conceptual framework so that they can answer the question: What are computers good for in education? At present, these issues are being researched and debated; but many schools are acquiring computer hardware before clearly thinking about the functions it will serve. Preservice education is extremely important in helping future teachers to formulate answers, and in determining how the technology will be used in educational contexts.

In our work at the Center for Children and Technology, we have been conducting research with children, teachers, and technology, teaching adults about computers in education, and developing software for educational settings. In this paper, I want to raise some of the issues that we consider to be important. First, I will present an overview and then, as illustration, will discuss some of the work we are doing.

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In education (i.e., computers used by students), computers can be thought about in two ways: (1) as tools that can be used to provide learning experiences (e.g. math CAI programs, simluations); and (2) as an increasingly pervasive technology in our society. Computers are something that students will have to know about. They are being incorporated into work settings, homes, and most predictions suggest that people are going to have to know how to make use of them.

But computers aren't just one thing (e.g., a lesson-deliverer). They are many things (a word processor, a data-recording device, a simulation machine), and we see them in more settings every day. While the business world and the communications industry are effectively adapting the technology to their purposes, education has lagged behind in thinking about effective ways to use and integrate computers into the existing educational context. Computers are machines which teachers and students should be able to understand and use flexibly. The first important thing to think about is how to adapt the technology to the needs of the particular setting--in this case, schools and classrooms. Interviews that we have conducted with students (fourth and sixth graders) suggest that they understand the computer in two ways: (1) as a game machine, which is what kids do with them; and (2) as something used in "research" by adults. Children will benefit from experiencing computers in a variety of ways: those that make use of the motivational power of computers as game devices, and those that expand children's ideas of what computers can be used for.

Why has education lagged behind? There have been two serious barriers to the effective use of these tools. First, there is a lack of high quality software that integrates the unique features of computers with the needs of teachers and students. Currently, the software isn't really helping to develop the potential of the technology. This is due to the lack of sufficient resources devoted to research and development in the publishing industry and by independent software developers, and the lack of careful, innovative thought about how best to use the technology. Second, since the educational application of computers is a recent innovation, most teachers have not been adequately trained in how to think about them. These two barriers go hand in hand. Teachers aren't sure how to use these new tools in a context that already functions without them, and many people who develop software haven't really thought through what goes on in an educational setting.

Right now, we are in a unique position with computer technology--it is pervasive and promises to stay. It is necessary simultaneously to

adapt it to educational purposes and to think about how to train teachers to use it, both of which are large enterprises. But those involved in preservice education are in a particularly good position to think about the issues surrounding computer use, and to help students develop a framework for thinking about them. Preservice education is a good time to reflect about the classroom context. It is these pressing and unanswered questions--how to use technology in classrooms, and how to think about its potential for changing education in a broader way--that should engage students.

If the computer is such a powerful tool, what is it good for? Some tentative categories for thinking about its use in education are:

- to deliver information and check answers, as in computer-assisted instruction (e.g. CAI or intelligent CAI in math or spelling);

- to provide unique learning experiences that take advantage of the special features of the technology. Simulation programs, for example, offer students experience in manipulating properties of a "world." The dynaturtle, developed by Andy DiSessa of MIT, gives students practice in manipulating an "object" in a simulated Newtonian world;

- to influence social aspects of classroom life, for example, children collaborating with each other in their work;

- to provide information about, and practice with, the technology itself. This is based on the assumption that computers are important cultural objects for children to know about. A variety of experiences with computers can help children to develop skills important for future work.

I am going to focus on the last three categories--unique learning experiences, social aspects, and information about the technology itself. Most currently available software (about 95%) is of the first type--to deliver information to users. In a sense, this function simply uses the technology in traditional ways--to provide information as do books, and to question students and check answers. Computers might perform these functions more effectively or more efficiently but, in this capacity, the computer would simply be replicating an old educational function. The incorporation of computers into an established function is similar to the way in which other new technologies have been assimilated. For example, the first films were simply recordings of plays, and did not take advantage of the tech-

nology's potential for presenting drama in new ways, such as closeups or juxtaposing shots in the editing process.

Thus, while drill-and-practice programs in education do serve a specific purpose, computerizing this function does not take full advantage of the technology for providing learning experiences. Computers allow users to organize and manipulate information rapidly, to play with the interactions among variables in problem solving, to simulate situations, and to process enormous amounts of information very quickly.

At Bank Street, we have been conducting a program of research and development that addresses some of these issues. I will focus mainly on our software development work, which has been guided by several assumptions:

- to make good software for learning. This means doing a full program of careful research in order to understand what children comprehend and learn as they work with particular pieces of software;
- to make software usable in classrooms. This means understanding the context in which it will be used, and testing the software in classrooms;
- to take advantage of the unique, powerful features of the technology;
- to provide different kinds of experiences with computers which illustrate a variety of ways in which they are useful tools.

Below are brief descriptions of three programs of research that we have been conducting at Bank Street:

1. In collaboration with Intentional Education in Cambridge, we have developed and tested a word processor for children. This tool, the Bank Street Writer, is now available for use in homes and schools. The software grew out of a research project to investigate how the use of a word processor might influence children's writing skills. One of the important things that has been noted about good writers is that they do a lot of revising. In addition to providing physical support for the writing process, a word processor may encourage children to revise their work because it's easy to change words and sentences, to move blocks of text around, and to try out different ways of saying something. In the initial stages of this project, a variety of available word processors were tested with children, but none was found to be suitable for use in classrooms.

While the children enjoyed using these tools, the available word processors contained unnecessary and difficult features which got in the way of carrying out the task of writing. Therefore, we decided to design our own word processor that would be simple for children to use, while at the same time providing them with the powerful features that this tool offers.

The Bank Street Writer is an example of a piece of software that can be integrated into classrooms fairly easily. The computer became part of the classroom context as a tool that extends a task already being done--writing. Thus, it fit neatly into an already existing educational function, while illustrating to teachers and students some of the unique capabilities of the technology.

2. In another project--the Project in Science and Mathematics Education, funded by the Department of Education--we developed and tested three pieces of software for use in science and math education. This project, directed by Sam Gibbon, is designed to effectively integrate three different technologies--television, microcomputers, and videodisc--for teaching science and math concepts to fourth through sixth graders. The television series presents information to students through a dramatic format: scientists, accompanied by young crew members, set off in a technologically equipped sailboat to study whales. Whales have been found to be a particularly attractive topic to children of this age. The scientific concepts are illustrated through the actual work of scientists in problem-solving situations.

The three software pieces develop different concepts, and illustrate different uses of the technology. The first, "Probe," allows children to measure physical inputs and to record this information graphically on the screen. Currently, children can measure temperature by taking readings with a sensor that is attached to the computer. Eventually, we plan to include light and sound into this data-measuring and recording utility. The children also learn about graphing as a format for representing information. Probe is a series of programs that give children practice in understanding the features of graphs. Beginning with simple measurement through a representation of a thermometer, they proceed to bar graphs, to the understanding that time can be represented as a line, and to the construction of a 2-axis graph. Thus, this software allows children to use computers for the scientific function of data measuring and recording, teaches them about certain physical phenomena, and gives them practice in graphing. Based on our research, the programs were modified several times to maximize children's understanding of and ability to use the software.

The second piece of software, "Rescue Mission," is a computer simulation of a navigation problem. Children must make use of information from a variety of navigation instruments (radar, radio direction finder, chart, binoculars) in order to navigate their ship to rescue a trapped whale. The children must develop a strategy for sequencing and using the computer-generated navigation information. This software was designed as a cooperative game where teams of children work together to solve the problem. The game was designed to take into account particular management issues raised by having only one computer in a classroom for many children. By rotating teams, many children can be involved with the computer activity at one time. We have found that this use of the computer as a simulation instrument in the context of science/math is a relatively new concept to teachers. Successful use requires some teacher preparation and some student activities. We are currently devising means of modifying the software so that some of this preparation and support is offered by the software itself.

Finally, two pieces of software, designed by Barbara Dubitsky of Bank Street, take on the task of helping children to learn elements of the Logo programming language. Designed as games, "Whale Search" and "Treasure Hunt" give children practice in several of the basic commands of the language. We intend to develop a package of games that will progressively build knowledge of the important elements of the language. Eventually, children will be led to construct their own programs and, perhaps, to seek further instruction in programming. This software may be particularly beneficial in classrooms where teachers have little familiarity with programming.

3. In a research project funded by the Spencer Foundation, we are examining how children learn to program with Logo, and the potential cognitive and social impact of this experience with computers. This is a novel use of computers in classrooms, and we have found that teachers have to think about how to integrate programming into the life of the classroom. We are interested in how teachers adapt to this novel area, and also in investigating the broader claims being made about the cognitive benefits of learning to program. For example, is programming a particularly powerful context for learning about planning and problem solving? One finding from this work thus far is that children tend to collaborate with each other more when they are working with computers. We have completed two studies which indicate that children talk with each other about the task they are engaged in when they are working on a computer problem more frequently than they do in other classroom tasks where they are encouraged to work together (e.g., math and language arts).

Our research suggests that it is important to think about and test ideas about the possible benefits of certain computer uses in classrooms. The three projects briefly described above illustrate a variety of ways of thinking about using computers in classrooms:

- as tools (a word processor, a data-measuring and recording device);
- as simulations where children can play with variables in problem-solving environments;
- in order to teach programming skills.

These uses vary in their ease of assimilation into current classrooms. The best "fit" seems to be the word processor, which extends a task--writing--that is already being performed in most classrooms. The software is easy to understand and use, and most teachers are comfortable with the idea that a computer can be used as a writing tool. Although fitting into an existing curriculum area, Probe and the navigation simulation are less easily assimilated into classrooms because they do some novel things, and require considerable teacher preparation to understand and use the software with students. Finally, the most novel function is programming. We have found that some teachers think of this as a new curriculum area and feel that they must be committed to extensive preparation in order to teach programming effectively, while others think of programming as a basic skill which should be learned.

It is necessary to think further about where in the classroom and curriculum the technology could be used to do interesting things, where it could be assimilated to what already exists, and how learning experiences could be extended by making use of what is novel and powerful about computers.

What does all this mean for teacher preservice education? First, the preparation and thinking that is required for a teacher to make good use of the technology is not simple. The training cannot be done in a single workshop or on a weekend. The technology is new to many people, and requires time and practice in order to gain facility. Second, while programming expertise may not be necessary (this takes years of focused training), some experience with programming, as well as with the various functions of the computer, is needed. In order to develop an indepth sense of what computers are, how they work, and what can be done with them, people need the opportunity to get their feet wet. Students should be able to use them for a significant period of time. Third, as part of this learning process,

students should be able to get expert feedback, to have access to someone who can help them with mistakes and introduce them to new concepts at appropriate points in their progress. Finally, as has been emphasized throughout this paper, students should have the opportunity to think critically about the functions of computers in education. This reflective process should occur at two levels. Students should be encouraged to think about how to use computers in their future classrooms and to develop personal preferences for their use. In preservice training, students can think about computers in the context of educational theories and practice; they can be helped to build a framework for flexibly incorporating this powerful tool into the classroom. At another level, claims are being made about how information technologies, particularly computers, will significantly change the organization of American education. These issues concerning the place of technology in education should be comfortably and knowledgeably debated by those who will be the teachers of the future.

The development of taste and perspective comes from understanding the characteristics of the computer as a tool in the context in which it is used. Focused attention and thinking about technology as a part of preservice education can not only make future teachers computer literate, it should aim to develop a conceptual framework, a critical attitude that can help to shape the way technology becomes a part of education.